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(Name of invention)

MOLD FOR OPTICAL DISC SUBSTRATE AND MANUFACTURING METHOD OF THE SAME

Outline

(Object)

Manufacturing of an optical disc substrate which can be used for recording all the way to the outer periphery.

(Solution)

This invention uses a mold 41 for an optical disc substrate where the molding surface 46 for molding the outer periphery of the optical disc substrate consists of a heat insulating layer 13. This heat insulating layer 13 controls residual stress due to rapid cooling of resin at the outer periphery of the substrate and also prevents an increase in birefringence of the substrate.

Sphere of request of the patent

(claim 1)

In the field of injection molding optical disc substrates, claim 1 is regarding a mold for an optical disc substrate where the molding surface for the outer periphery of the optical disc substrate consists of a heat insulating layer.

(claim 2)

Claim 2 is regarding the mold for optical disc substrates in claim 1 where the heat insulating layer consists of materials with 4.0 W/m·K or less thermal conductivity and also has 400 or higher Vickers hardness.

(claim 3)

Claim 3 is regarding the mold for optical disc substrates in claim 2 where the heat insulating layer consists of yttria stabilized zirconia or barium titanate.

(claim 4)

Claim 4 is regarding the mold for optical disc substrates in claim 2 where the heat insulating layer is at least 0.3 mm thick.

(claim 5)

Claim 5 is regarding the mold for optical disc substrates in claim 1 where it also has a stamper for forming the recording surface of the optical disc substrate, a core for supporting the stamper, and a heat insulating part set up between the stamper and the core.

(claim 6)

It is regarding the details of the molding process in this manufacturing method for optical disk substrates which uses the mold for optical disc substrates in claim 1.

Detailed explanation of this invention

[0001]
(Technical field of this invention)

This invention is regarding a mold for optical disc substrates and a manufacturing method for the same.

[0002]
(Prior art)

Formerly optical disc substrates have been manufactured by injection molding. This former mold 40 is, as shown in figure 4, furnished with a fixed mold 42 and a movable mold 41. The movable mold 41 is furnished with a stamper 4 made of nickel which has projections 11 for forming data pits or laser guide grooves, a stamper I.D. clamp 7 and a stamper O.D. clamp 8, a movable mold core 5a, a center hole punch 9, an ejector 10, and a cooling circuit 12. Meanwhile, the fixed mold 42 has a fixed mold core 5b and cooling circuit 12. Also, figure 4 shows the optical disc substrate 6 before releasing from the mold and after both molds 41, 42 have been separated. In addition, an enlargement of area 43 is shown inside circle 43a.

[0003] When the fixing mold 42 and movable mold 41 are combined, a cavity is formed by the molding face 44 of the stamper 4 which has been fixed inside the movable cavity by the stamper I.D. clamp 7 and O.D. clamp 8, the rear surface 45 of the core 5b of the cavity 42, and the outer periphery 46 of the stamper O.D. clamp 8. Molten resin flows through the gate 47 in the center of substrate and fills this cavity. After the resin cools and is solidified, the mold 40 is opened. The molded product is released and ejected by an ejector 10, and the optical disc substrate 6 is acquired.

[0004]
(Problems that this invention tries to solve)

Recently, an increase in the data capacity of the substrate has been requested. However, substrates which have been molded by the former method such as the one above have higher since retardation (birefringence) at the outer periphery and it has been impossible to make the area within approximately 2 mm of the outer edge usable for data storage. Therefore, the object of this invention is to offer a manufacturing method and a mold which can be used to manufacture optical disc substrates with more recordable area than was formerly the case.

[0005]
(Step for solution)

In order to solve the above problems, the phenomenon of birefringence at the outer periphery was studied thoroughly. As a result, it was found that the melted resin cools rapidly below the glass transition temperature of the resin when it comes into contact with the outer periphery of the cavity. When melted resin is rapidly cooled to temperatures lower than the glass transition temperature and solidified, birefringence is rapidly increased due to thermal stresses caused by rapid cooling.

[0006] Therefore, in this invention, a mold for optical disc substrates with a heat insulating material on the outer periphery of the optical disc substrate is used. This invention also offers a manufacturing process which uses this mold. The heat insulating layer on the mold face which forms the outer periphery of the substrate controls thermal

stresses due to rapid cooling at the outer periphery of the substrate and also prevents increasing birefringence at the outer periphery. Thus, according to this invention, the substrate can be recorded very close to the outer periphery.

[0007]
(State of practice of this invention)

The material used for the heat insulating layer in this invention should have 4.0 W/m·K or less thermal conductivity and 400 or higher Vickers hardness as a thin film. If the thermal conductivity is high, effective insulation cannot be acquired. If the hardness is low, the substrate will be deformed by molding pressure. Materials which have such thermal conductivity and Vickers hardness include, for example, zirconia based ceramics or titania based ceramics. Any of these could be used as the heat insulating layer of this invention.

[0008] As zirconia based ceramics, for example, there are yttria-stabilized zirconia (ZrO_2: 92 mol %, Y_2O_3: 82 mol %). The thermal conductivity of this ceramic is approximately 3.7 W/m·K, and their Vickers hardness is 500 to 600. Titania based ceramics include, for example, barium titanate (TiO_2: 50 mol %, BaO: 50 mol %). The thermal conductivity of these ceramics is approximately 2.9 W/m·K, and their Vickers hardness is 400 to 500.

[0009] The heat insulating layer which consists of such ceramics can be formed by making a separate plate-like part by sintering ceramics and applying it to a predetermined part of mold, or by forming it directly on the surface of the predetermined part by sputtering, etc. However, it should be formed by the plasma spraying method since a thin film can be formed fast. In addition, when an especially flat molded surface is demanded, it is possible to re-polish the surface of the film formed by plasma spraying.

[0010] Production of thermal stress during the molding process is due to the fact that resin is rapidly cooled to a temperature lower than the glass transition temperature of the resin by the walls of the mold cavity. To control production of thermal stress, the temperature of the cavity wall must be higher than the glass transition temperature of the resin at least at the point where the mold is filled.

[0011] Therefore, the temperature of the resin at the interface and the wall temperature were sought in the case when the thermal conductivity of the heat insulating materials used for the insulating layer had a thermal conductivity of 4.0 W/m·K and molding conditions were 125°C mold temperature and 350°C resin temperature. The results are shown in figure 2. The injection time required for the resin to reach the outer wall was estimated as 0.2 second, and the resin temperature 0.2 second after introduction of the resin was sought. The mold cavity was stainless steel (thermal conductivity: 25 W/m·K). The resin was polycarbonate (thermal conductivity: 0.188 W/m·K, glass transition temperature: 147°C). In addition, when there was no heat insulating layer (when resin contacts the mold directly), the temperature at the interface was approximately 136°C.

[0012] As is understood from figure 2, if the thermal conductivity of the heat insulating material is 4.0 W/m·K, when the heat insulating layer is at least 0.3 mm thick, the temperature at the interface between the resin and the heat insulating layer will be higher than the glass transition temperature (147°C) of the polycarbonate resin which is the substrate material. Therefore, the heat insulating materials should be at least 0.3 mm thick.

[0013] The mold in this invention should have heat insulating materials between the stamper 4 and movable core 5a. By reducing the cooling rate of the resin at the outer periphery, it is possible to make the cooling rate uniform over the entire substrate. Thus, transcription of the pattern on the stamper 4 will be uniform and also good. This also prevents deformation caused by releasing the product from the mold.
[0014] It is possible to make this heat insulating material gradually thicker from the inner periphery toward the outer periphery in accordance with the distance from the center just like part 51 shown in figure 5. By making it this way, even if the outer periphery is thick, excessive cooling time can be prevented. In this case, the outer edge should be at least 0.2 mm or thicker and the inner edge should be 1.0 mm or thinner. It is also acceptable to make the thickness of the heat insulating materials uniform. In this case, the thickness should be in the range of 0.2 mm to 1.0 mm. If the thickness is 0.2 mm or more, even if the resin reaches the outer periphery, its temperature is still be higher than the thermal deformation temperature and sufficient transcription performance can be secured. If it is less than 1.0 mm, since the cooling time of a 120 mm diameter substrate can be less than 2 seconds, productivity will be sufficient.
[0015] In the following, examples of practice of this invention are going to be explained using figures.

Example of practice 1

(1) mold

First the mold in this example of practice is going to be explained. The area near the stamper 4 of the movable mold 41 of the mold in this example of practice is shown in figure 1. In the movable mold 41 of this example of practice, as shown in this figure 1, the face of the outer periphery 46 of the stamper O.D. clamp 8 is covered by a heat insulating layer 13. Other than this, the construction of the mold in this example of practice is the same as the mold shown in figure 4.
[0016] This heat insulating layer 13 consists of yttria-stabilized zirconia (ZrO_2: 92 mol %, Y_2O_3: 82 mol %),and it is a band of thin film 10 mm wide and 0.3 mm thick. The Vickers hardness of this film is 500 to 600. Also, in this example of practice, this zirconia heat insulating layer was formed by plasma spraying. That is, ceramic powder was heated higher than 3000°C and was melted, and it was dissolved and injected to the predetermined region of the stamper O.D. clamp 8 at 100 to 300 m/seconds. By doing this, the heat insulating layer 13 was formed.
[0017] The stamper 4 in the mold in this example of practice is disc shaped with a hole through the center. The nickel stamper measures 140 mm outer diameter, 20 mm inner diameter, and 0.3 mm thick. In addition, the outer diameter of its mold face 44 is 120 mm. In this example of practice, stainless steel (thermal conductivity: 25 Wm·K) was used for mold parts other than the stamper and heat insulating layer.
[0018]

(2) Molding of the substrate

The mold above was kept at 125°C, and polycarbonate resin ("Panlight AD5503"manufactured by Teijin Kasei) at 350°C was used to fill the cavity. After it was cooled and released from the mold, an optical disc substrate with 120 mm diameter and 10mm thickness was manufactured. The thermal conductivity of this polycarbonate resin

was 0.188 Wm·K, and its glass transition temperature was 147°C. Distribution of retardation (birefringence) in the acquired substrate is shown as "O" in figure 3.
[0019] In this example of practice, since the temperature of the molten resin right after it reaches the outer periphery of the substrate is higher than the glass transition temperature of the polycarbonate resin, this would not constitute so-called "rapid cooling." Because of this, as is understood from figure 3, production of thermal stresses near the outer edge could be controlled. Also, the area within a 59.5 mm radius had a birefringence (retardation) distribution which is usable for recording.
[0020] Also in this example of practice, although the stamper O.D. clamp 8 is used as part of the cavity wall for forming the outer periphery of the substrate, this invention is not limited to only this. Depending on the mold construction, simple ring-shaped parts of the outer periphery are used as part of the cavity wall to form the outer periphery of the substrate. However, in such cases, a heat insulating layer can be used behind these rings.

[0021]
Example of comparison

Except that the mold 40 shown in figure 4 was used, the same procedure was followed as in example of practice 1, and an optical disc substrate was manufactured. The retardation (birefringence) distribution of the acquired substrate was measured. Results are shown in figure 3 as ●. As is understood from this result, in the substrate which was formed using the former mold 40, up to approximately 2 mm inside from outer edge of the substrate could not be used for recording because of increased retardation. In other words, only 58 mm of the 60 mm substrate in this example of comparison was usable for recording.

[0022]
Example of practice 2

Except that a heat insulating part 51 which consisted of yttria-stabilized zirconia (ZrO_2: 92 mol %, Y_2O_3: 82 mol %) was set up between the stamper 4 and the movable core 5a, the same kind of mold as in example of practice 1 was used, the same procedure as example of practice 1 was followed, and an optical disc substrate was manufactured. The results were the same as in example of practice 1. A substrate which could use the area up to 59.5 mm radius from the center for recording was acquired. The heat insulating part 51 shown in figure 5 was a disc-shaped part with a hole through the center with 140 mm outer diameter and 20 mm inner diameter. It covered the total rear surface (surface opposite the molding surface 44) of the stamper 4. The thickness at the inner periphery of this heat insulating part 51 was 0.13 mm, and it becomes gradually thicker with increasing distance from the center. It reaches 0.6 mm at the outer periphery. This heat insulating material 51 is made by the following process. First, a ceramic composition is sintered formed into a predetermined shape. It is polished to a flatness of less than 0.1 mm planar degree and less than 0.3 μm surface roughness (Ra). Using epoxy adhesive, it was attached to the movable core 5a which had been made thinner by the thickness of this material 51.
[0023] In this example of practice, in addition to the effects achieved in example of practice 1 - that the retardation (birefringence) at the outer periphery is low and the usable area is larger, it is also possible to precisely transcribe sub-micron data pits or to

form a laser guiding groove with good accuracy. Not only that, warp and deformation of the substrate can be minimized.

[0024]

Example of practice 3

As shown in figure 6, except that the thickness of the heat insulating material 61 between the stamper 4 and movable core 5a is uniform, the same procedure as example of practice 2 was followed, and an optical disc substrate was manufactured. As a result, a good substrate like the one in example of practice 2 was acquired. The heat insulating material 61 of this example of practice was 0.2 mm thick. It is applied to the surface of the movable core 5a which has been made thinner by 0.2 mm compared to example of practice 1. The heat insulating layer was formed by the plasma spraying method the same as example of practice 1. It was polished to less than 0.01 mm planar degree and less than 0.3 μm surface roughness (Ra).

[0025]

(Effects of this invention)

As explained above, according to this invention, an optical disc substrate with a large recordable area - up to the very end of the substrate is offered.

(Simple explanation of figures)

Figure 1: partial section of the movable part of the mold for optical disc substrates of example of practice 1.

Figure 2: graph which shows the relationship between the thickness of the heat insulating layer and resin temperature at the interface at the O.D.

Figure 3: graph which shows the retardation distribution of the optical disc substrate in example of practice 1 and in the example of comparison.

Figure 4: section of former mold for optical disc substrates.

Figure 5: partial section of the movable part of the mold for optical disc substrates in example of practice 2.

Figure 6: partial section of the movable part of the mold for optical disc substrates in example of practice 3.

(Explanation of numbers in figures)

4: stamper

5a: movable mold core

5b: fixed core

6: optical disc substrate

7: stamper I.D. clamp

8: stamper O.D. clamp

9: center hole punch

10: ejector

11: projection for forming data pits or laser beam guiding groove

12: cooling circuit

13: heat insulating layer

40: former mold

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41: movable type
42: fixed type
43: enlarged region which shows the molding face of the stamper
43a: enlarged figure
44: molding face for the surface of substrate
45: molding face for the rear side of the substrate
46: molding face for the outer periphery side face of substrate
47: gate for introducing resin
51, 61: heat insulating part of the rear face of stamper